CHAPTER 2
SURFACE RECYCLING OF PAVEMENTS

2-1. General.

When a pavement is structurally sound and rehabilitation is needed to correct a surface problem, surface recycling should be considered. The three surface recycling processes discussed in the following paragraphs are rejuvenating, heater-planing-overlaying, and cold milling. The basic procedures for surface recycling are shown on the flow chart in figure 2-1.

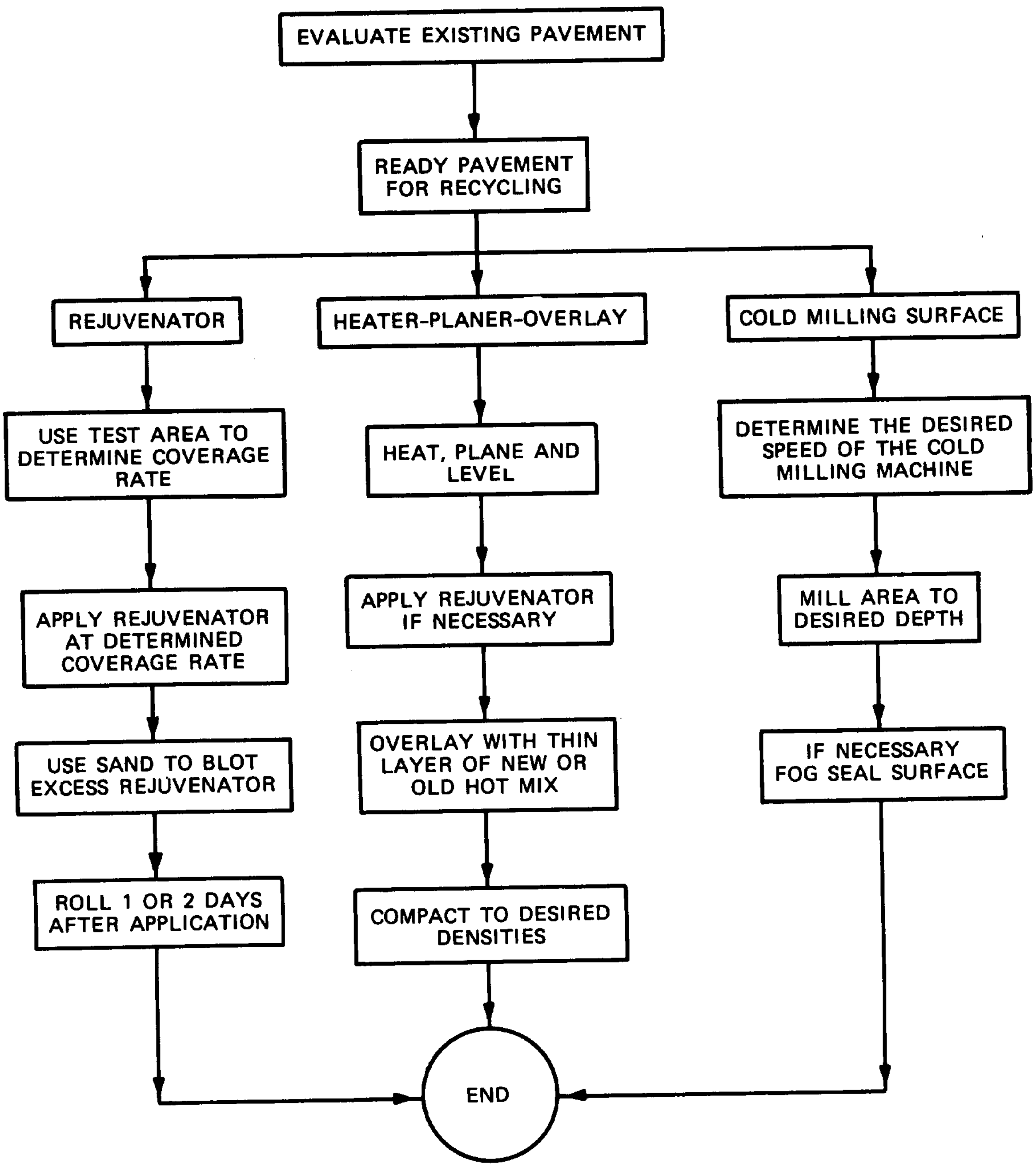

Figure 2-1. Surface recycling flow chart.

2-2. Equipment.

The major pieces of equipment required for surface recycling techniques are conventional asphalt distributor for rejuvenating, heater-planer and motor grader or self-contained heater-planer-paver, broom, trucks, and front-end loader for heater-planing-overlaying, pavement milling machine, broom, and trucks for cold milling.

2-3. Rejuvenating.

The application of a chemical rejuvenator provides penetration of a chemical into bituminous pavement which plasticizes the binder. Rejuvenators can be sprayed directly on the surface of a bituminous pavement, as in figure 2-2, or they can be used in conjunction with heater-planing-scarifying and cold milling recycling processes.

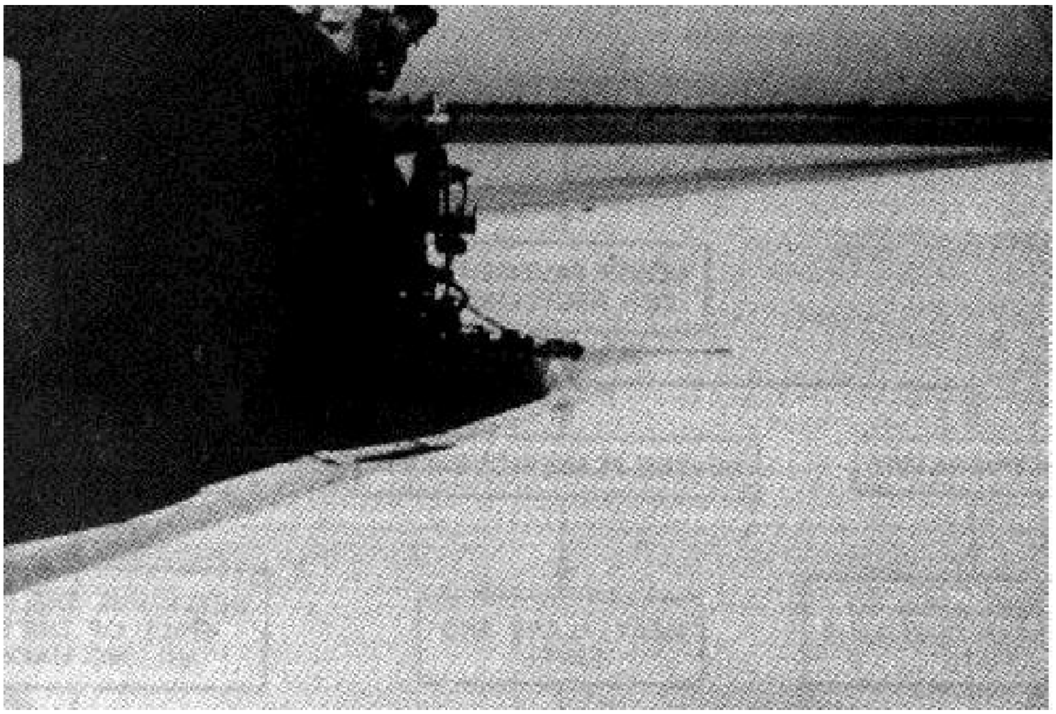

Figure 2-2. Asphalt distributor applying rejuvenator.

a. Properties of rejuvenators. Some of the properties of rejuvenators are described below.

(1) The application of a rejuvenator to a bituminous pavement partially restores its original asphalt properties. However, for a rejuvenator to be successful, it must penetrate the pavement surface and soften the asphalt rejuvenator, the weather conditions, and the permeability of the pavement surface.

(2) When a rejuvenator is applied to a pavement in which the asphalt binder is oxidized, it will retard the loss of surface fines and reduce the formation of additional cracks. Application of a rejuvenator will also reduce the skid resistance of the pavement for up to 1 year. While this reduction in skid resistance should not be significant for parking aprons and taxiways, it may be significant for runways or other areas where high aircraft speeds are likely to occur. Use caution; be sure to have a full-time person on the job who is experienced in applying rejuvenators.

(3) A rejuvenator should not be applied to a bituminous pavement having an excess of binder on the surface such as that found in slurry seal, porous friction course, or bituminous surface treatment. When excessive binder is on the surface, the rejuvenator will soften the binder and cause the surface to become tacky and slick.

(4) The amount of air voids in the bituminous mixture being rejuvenated should be at least 5 percent to ensure proper penetration of the rejuvenator into the pavement. However, if the voids are less than 5 percent, the rejuvenator may fill the voids and thus cause an unstable mix.

(5) Care must be used in selecting a rejuvenator. Some rejuvenators perform satisfactorily, but many do not. The rejuvenator selected for use should have a proven record of satisfactory performance. However, if performance data on a particular rejuvenator are not available, the rejuvenator should be applied to a test area on the pavement and evaluated over some period of time to determine its potential performance.

(6) It is desirable to change the properties of the asphalt in the top approximate % inch of material so that the asphalt cement approaches its original properties. Test results have shown that the viscosity test is more effective in determining a change in asphalt properties than the penetration test. Although application of a small amount of rejuvenator will be reflected by the viscosity test, the penetration test may indicate very little or no change in asphalt property.

(7) Rejuvenators should be applied in hot weather, above 70 degrees F, so that the rejuvenator will penetrate more deeply into the asphalt pavement and will cure sooner.

b. Application of rejuvenators. When applying a rejuvenator, the following must be considered.

(1) The asphalt distributor is the key piece of equipment used to apply asphalt rejuvenators. It is essential that the distributor is in proper operating condition when rejuvenators are applied to ensure that the rate of application is uniform. Figure 2-2 shows a distributor properly applying a rejuvenator to an asphalt concrete pavement. An inspection of the distributor should ensure that:

(a) The distributor has a circulating tank so that the rejuvenator can be thoroughly mixed prior to spraying.

(b) The motor is in proper running condition so that it does not misfire when accelerating and cause varying rates of rejuvenator to be applied.

(c) The size of the spray nozzles is selected so that a smooth consistent spray is obtained over the range of desired application rates.

(d) All spray nozzles are the same size and are set at the same angle with the spray bar.

(e) The spray bar is at the correct height to provide either a double or triple overlap.

(f) The application rate is checked to verify proper calibration.

(2) Before rejuvenator is applied to the pavement, several test sections should be constructed and the rejuvenator should be applied to the sections at various rates to determine the proper application rate. Generally, the application rate should not exceed that which will allow the rejuvenator to penetrate the pavement within 24 hours.

(3) The amount of rejuvenator needed to properly modify the asphalt binder may not be the same amount needed to penetrate the asphalt pavement. The determinations made from the test sections should dictate the amount of rejuvenator that can penetrate the asphalt pavement, and this amount should never be exceeded. The optimum benefit will be obtained by applying the maximum rate that will penetrate the pavement.

(4) When rejuvenator is applied to the pavement, clean dry sand should be available to blot areas that received too much rejuvenator. The sand should be evenly spread over these areas, broomed into a pile, and removed. Rolling the pavement surface 1 or 2 days after rejuvenator has been applied may help to knead and to close hairline cracks.

2-4. Heater-planing-scarifying.

a. Heater-planing. Heater-planing consists of heating the surface of a bituminous concrete pavement and planing the surface to the desired grade. In recent years, the cold-milling operation has essentially replaced heater- planing for airfield work.

b. Planing operation. The planing operation may require one or more passes of the equipment to obtain the desired depth of cut. The equipment used to plane a pavement varies considerably. Some of the equipment, as shown in figure 2-3, is self-contained so that one piece of equipment can heat, plane, scarify, or add binder and hot mix. Other equipment is not self-contained. In fact, often planing and scarifying are done with several pieces of equipment, such as a heater which can heat and scarify, a planer, which usually is a motor grader, a distributor to add binder material, and a laydown machine. A heater-planer with scarifying teeth followed by a grader is shown in figure 2-4. Usually, when planing and scarifying are required, several passes may be necessary to plane the pavement to the desired depth before scarification. The planed pavement is then reheated and scarified to a depth of¾ to 1 inch. Some planers use direct flame to heat the pavement surface, and others use radiant heat. The heater in figure 2-4 uses direct flame for heat, and the heater in figure 2-3 uses radiant heat.

c. Planing pavement. Caution should be used when planing an existing pavement to a desired grade. Since the planing operation usually consists of removing the heated material to a design grade, an experienced operator is required. Two to three passes of the heater and planer may be necessary in some areas to obtain the desired grade.

d. Removed material. The removed material can be used best while hot to provide a low-quality bituminous mixture where a low-quality mix is acceptable. Kerosene or other solvents are often mixed with the removed material to form a cold mix that can be stockpiled. Often, the quantity of material removed is so small that it is impractical to use the planed material. Also, once the material cools and hardens, it is difficult to reuse.

e. Scarifying process. Scarifying the pavement surface prior to overlay can minimize some existing pavement problems such as bonding if the pavement surface has become polished over a period of years from the action of traffic. In this case, the surface can be scarified to promote a good bond between this existing polished surface

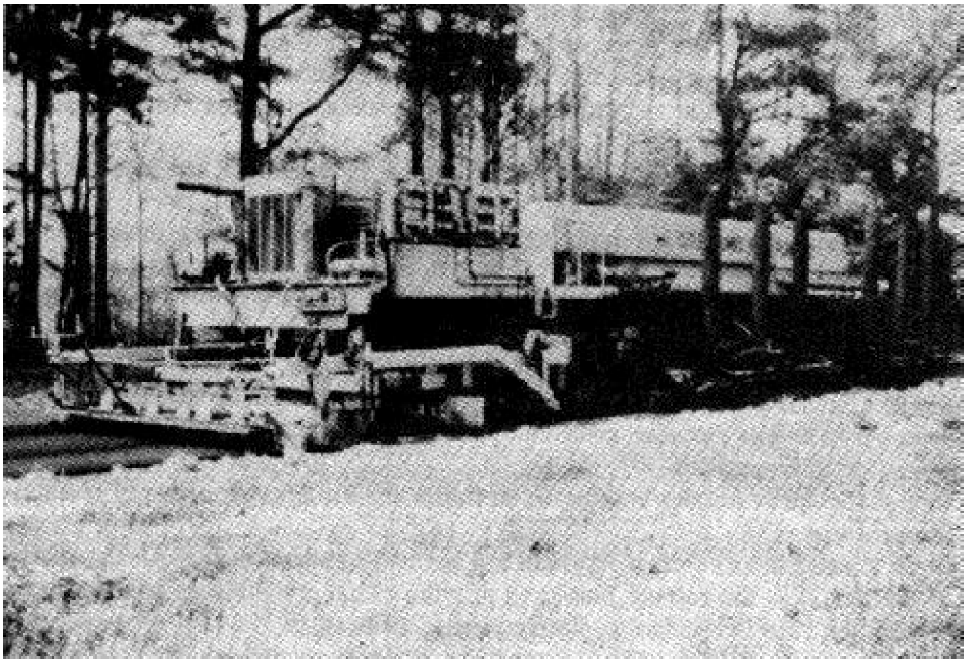

Figure 2-3. Self-contained heater-planer.

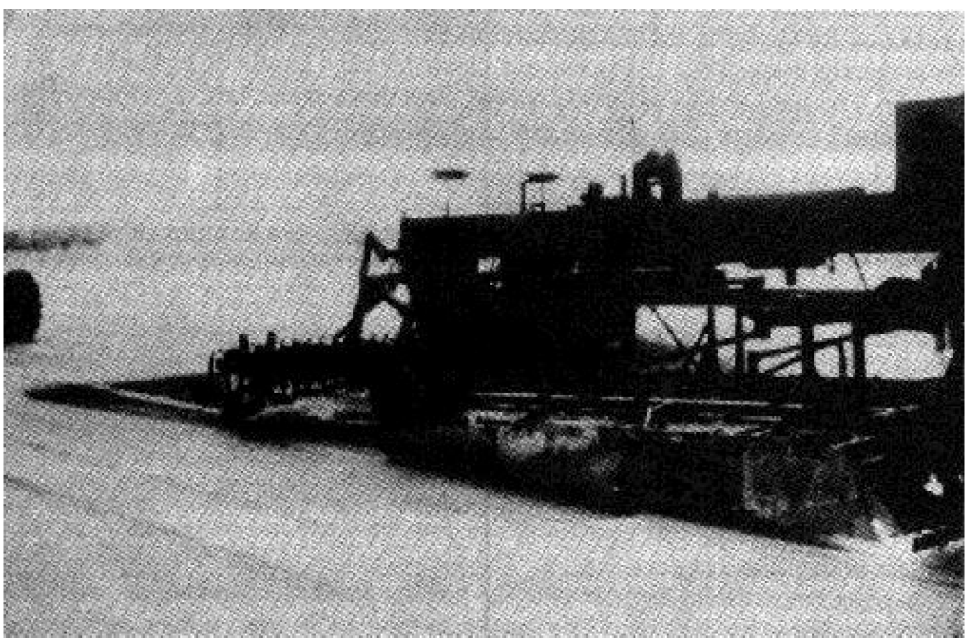

Figure 2-4. Heater with scarifying teeth followed by grader.

and an overlay. Scarification also breaks up the crack pattern and reduces the amount of reflective cracks that will appear in the overlay. Scarifying the top ¾ to 1 inch of the surface allows additional asphalt binder or rejuvenating agent to be added to the scarified material. This procedure is often used to maintain secondary roads to provide a tight waterproof surface. In most instances, the scarification process is followed by a bituminous concrete overlay.

f. Quality. The quality of mixes obtained by heating and scarifying existing pavements is difficult to control. The quality of the scarified and rejuvenated mixture depends on the depth of scarification, time of heating, amount of rejuvenator added, and amounts of compaction. When no overlay is applied in conjunction with the scarified material, it is necessary that the heated material be rolled immediately after being heated and scarified to ensure that a satisfactory density is obtained. Scarifying, rejuvenating, and compacting a surface without the addition of an overlay may cause an excess of coarse aggregate on the surface. This coarse aggregate makes the scarified material difficult to compact and results in a surface that tends to ravel. The scarifying, rejuvenating, and compacting procedure should only be used to improve the surface of mixtures on secondary roads.

g. Overlay approach. An overlay in conjunction with scarifying the pavement is recommended. The overlay may be added prior to compaction of the scarified material and both layers compacted simultaneously, or the scarified material may be compacted prior to addition of the overlay. To ensure better bond and better overall density, it is recommended that the overlay be placed immediately after scarifying the surface and the entire depth of material compacted. Although this scarification and overlay approach has been used on airfields, generally other alternatives should be selected.

h. Asphalt. The asphalt sampled from the scarified and rejuvenated material should show an improvement in properties over the existing asphalt properties. Generally, the penetration of the recovered asphalt binder should be 40 to 70. The amount of binder material added should not cause the voids in the compacted mixture to become overfilled and thus create an unstable mixture. To determine when a mixture is unstable, samples of the mixture should be obtained and compacted at 250 degrees F using the standard compaction effort for the job. When the voids of the compacted samples are less than 3 percent, the mixture should be considered unstable, and the amount of rejuvenator should be reduced.

i. Pollution. Pollution caused by smoke from the heating of the asphalt surface may be a problem. But the amount of smoke can usually be controlled within an acceptable range on most asphalt mixtures. However, heating of pavements that have numerous sealed cracks will present a problem since the sealer material usually causes an increase in the amount of smoke during the heating operation.

2-5. Cold milling.

a. Milling process. The milling process, which does not use heat, is used to mill a bituminous or portland cement concrete pavement to a desired depth. The milling equipment, which can remove up to 4 inches of bituminous mixture in one pass, uses sensors that follow a stringline grade reference and slope control to directly control the finished grade (fig 2-5). Since no heat is needed, the pollution problem caused by burning bitumen is eliminated. However, a problem with dust may occur, but this problem can usually be solved by spraying a small amount of water onto the pavement in front of the machine. The milling machine can be used during all weather conditions to produce a smoother grade.

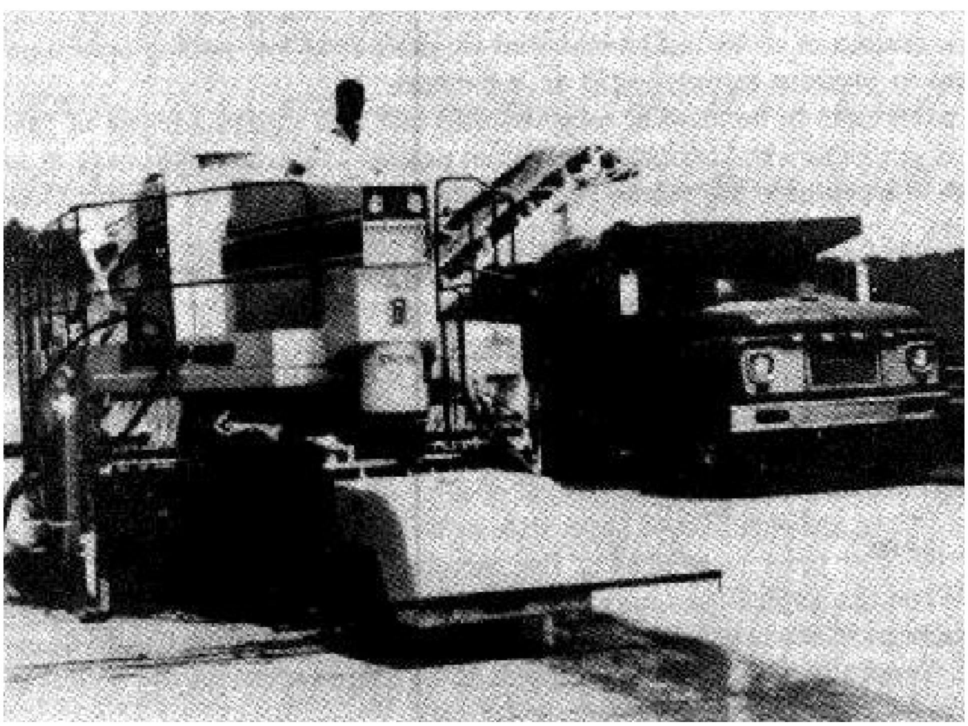

Figure 2-5. Pavement cold-milling machine in operation.

b. Cutting teeth. The cutting teeth on the milling machine are a high maintenance item and must be replaced often. The teeth may last 1 or 2 days, depending on hardness of the material being milled and the number of operation hours per day. The cutting teeth can be adjusted to provide a range of surface textures from smooth to very rough. When all the teeth are in position, the finished surface texture is smooth. By removing some of the teeth, the surface texture can be made rougher. When the milled surface is used for a riding surface, a rougher surface texture provides better skid resistance; however, the rougher surface also causes more tire wear.

c. Milling versus heater-planing. The reasons for milling are similar to those for heater-planing. The milling can remove bituminous or portland cement concrete pavement from bridges to avoid exceeding the maximum dead load. Also, areas adjacent to curbs, manholes, and other structures can be milled before an overlay is applied so that the overlay thickness can be maintained adjacent to these structures. One advantage the pavement milling machine has over the heater-planer is its ability to remove portland cement concrete pavement. This is particularly advantageous when milling a pavement that has some portland cement concrete along with the bituminous material that must be planed or removed, such as in areas adjacent to manholes or patches. The most extensive use of the milling machine is in pavement recycling. The removed materials can be mixed with new aggregate and new asphalt to produce recycled cold mix or recycled hot mix.

d. Milled surface. Occasionally, when a pavement surface has been milled, the surface is used as the riding surface for a period of time. For instance, when a pavement does not have adequate skid resistance but no immediate funds are available to overlay this pavement, one alternative is to mill the surface to give it a rough surface texture and thereby provide adequate skid resistance until it can be overlaid or otherwise repaired. An excessive amount of material should not be removed because the pavement structure would be weakened. It is recommended that the pavement be overlaid as soon after the milling as possible. Raveling may become a problem with asphalt concrete pavements after the milling process. On airfields, raveling could result in foreign object damage (FOD) to the aircraft. Therefore, an overlay should be applied immediately after the milling operation in most cases.

e. Milled material. The material obtained from milling operations can be used in pavement construction. The milled material can be stockpiled, but care must be exercised not to stockpile it too high, especially in hot weather, since the asphalt concrete material will have a tendency to bond thus making it difficult to use. In most cases, the material should not be stockpiled over 10 feet. The milled material can be used for producing recycled cold mix, recycled hot mix, and other mixes. Occasionally, this milled material can be used to surface secondary roads that otherwise would not be surfaced. In this case some additional binder material, such as asphalt emulsion or rejuvenator, is usually added to rejuvenate the old asphalt or improve binding qualities. This milled material, mixed with asphalt emulsion, can also be used as a base course for high-quality pavements. The material can be mixed in place or removed and plant-mixed to produce a satisfactory base course. For high-quality airfield pavements, this base course should be overlaid with the minimum amount of asphalt concrete mixture required by design. The hot mix and cold mix prepared from materials obtained by milling are discussed in chapters 3 and 4.

f. Gradation. The gradation of the milled material obtained from the milling operation is important when the material is to be used to produce recycled cold or hot mixes.

(1) When the material is to be used in recycled cold mix, the maximum size of the milled material, which is a conglomeration, of aggregate and asphalt, should not exceed 1½ inches. However, a small amount of material larger than 1½ inches is acceptable if it can be removed by screening prior to mixing. Generally, the milled material, without additional virgin aggregates, is used to produce recycled cold mix.

(2) When the milled material is to be used in recycled hot mix, the gradation of the milled material after extraction of the asphalt cement is important. Very little breakdown of the aggregate should occur during the milling operation. It is important that the maximum size of the material as milled does not exceed 1½ to 2 inches to ensure that it will break up and satisfactorily mix with the new materials in the production of recycled hot mix. Some filler material passing the No.200 sieve will be manufactured during the milling operation. Depending on the aggregate type, 1 to 3 percent additional filler may be manufactured. One of the problems in designing a recycled mixture is not to exceed the maximum amount of filler allowed. Generally, new aggregates that are to be added to a recycled mixture are required to have little or no filler. Therefore, washing of new aggregate is often required to remove the filler prior to producing the recycled mixture.

g. Base course. When the asphalt pavement material is to be removed down to the base course, care should be taken to prevent damage to the base course. Any damage to the base course should be corrected prior to placing the recycled mixture. Generally, approximately ½ inch of asphalt mixture should be left in place to prevent damage to the base course by the milling equipment or by rain.